A COMPUTER-ASSISTED TECHNIQUE FOR REQUIREMENTS VERSUS CAPABILITIES ANALYSIS IN BASE DEVELOPMENT PLANNING

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THESIS

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ABSTRACT

This paper presents a computer-assisted technique for requirements versus capabilities analysis in base development planning. The decision alternatives available to the planner are examined and a procedure for implementation in the planning process is proposed. Some unresolved problems in current base development planning methodology are described.

TABLE OF CONTENTS

LIST OF DRAWINGS

Figure

TABLE OF ACRONYMNS

CASTLE	Computer-Assisted System for Theater Level Engineering
CATECODE	An automated planning system
COBOL	Common Business-Oriented Language
D-DAY	Deployment day
D+10	Ten days after D-DAY
EFCS	Engineer Functional Components System
ESSG	Engineer Strategic Studies Group
JCS	Joint Chiefs of Staff
OPLAN	Operations plan
PRESCORE	Program for Estimating Construction Requirements
RAC	Research Analysis Corporation
SIGMALOG	Simulation and Gaming Methods for the Analysis of Logistics
TOE	Table of Organization and Equipment
US	United States

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I. INTRODUCTION

The long involvement of United States military forces in the Republic of Vietnam has evoked an unprecedented volume of public and private comment on both military and political actions in the conflict. The critical appraisal and analysis of the Vietnam related military operations by individuals and organizations within the defense establishment has provided the basis for a vast number of "lessons learned" on tactical and logistical problems. These lessons have, in turn, provided a basis for the improvement of military doctrine to preclude the repetition of past mistakes. One such lesson has been that extensive logistical facilities must be developed to provide support to modern combat forces during the initial stages of the force deployment.

The realization of the importance of early logistical base development has generated activity in each of the three major services and at the Joint Chiefs of Staff (JCS) level. The Joint Staff has published directives requiring that base development plans be prepared and updated annually in conjunction with each of over one hundred existing joint contingency plans designed to fulfill the numerous national defense commitments around the world. Each service has developed one or more base development planning systems to accomplish this task on a continuing basis.

The Engineer Strategic Studies Group (ESSG), Office, Chief of Engineers was tasked with the responsibility for development of such a planning system within the Department of the Army and began preparation of a computer-assisted system, identified as CATECODE, in early 1970. This paper resulted from the author's work on a portion of this system during a temporary assignment to ESSG as part of the Naval Postgraduate School's Operations Research/Systems Analysis curriculum. The paper describes: (1) the early versions of the CATECODE system, (2) the problem of requirements versus capabilities analysis, and (3) a solution to the problem. Several other problems which became evident during the study of the requirements versus capabilities problem are discussed briefly.

II. BASE DEVELOPMENT PLANNING

Base development is the means by which facilities comprising the physical plant are provided in sufficient quantities and types and in the proper locations to permit the timely and adequate initiation and sustaining of military operations in accordance with contingency plans. The United States currently has numerous worldwide commitments which could engage our military forces in areas where such facilities are either limited or non-existent. While Army doctrine has always recognized the importance of bases for support of combat forces, the severe constraint inadequate logistical facilities could impose on initial combat operations was not fully realized until the deployment in South Vietnam. Planning directives and guidance have always called for a logistics plan to be published as an annex to each operations plan. The logistics plan defines all logistic tasks and responsibilities in support of the operation. One such task is the construction of minimal base facilities, and thus the base development plan appears as an appendix to the logistics annex. Prior to the Vietnam experience commanders and planners conscientiously observed the requirement to consider base development when planning for contingency operations, but the level of detail was such that the location of ports, beachheads, depots and roads, and possibly their capacities was as definitive as the planner became. The deployment of a modern, well-equipped

force in South Vietnam revealed that such things as capacity and location of depots must be specified in far greater detail than before. The size and type of construction of maintenance facilities, petroleum storage, cross-country petroleum lines, and personnel support facilities for logistical and rear-area combat troops needed to be determined and provided for before the initial tactical deployment. If the facilities required to support the deployment could not be provided, the deployment must be slowed down until adequate support was available. Deployment before facilities are constructed could result in greatly diminished combat capability and excessive casualties.

As a consequence of the difficulties observed in South Vietnam because of the inadequate planning for construction of logistical facilities, the Department of Defense and the individual services moved almost simultaneously to improve the base development planning process. The first major effort within the Army was from the Engineer Strategic Studies Group and the result was the Base Development Planning Guide [Ref. 14] published in October 1967. This publication was designed as interim guidance to base development planners pending more definitive guidance from the Defense Department, and dealt mainly with manual, pencil-and-paper style, methods of base planning.

The Department of Defense published general guidance in December 1968 in the form of a manual entitled Base Development for Contingency Operations [Ref. 17], and in November 1969, the Joint Staff provided definitive guidance on the format and data elements to be incorporated

in each base development plan [Ref. 23]. The level of detail required by these formats and the volume of plans involved made it apparent that automatic data processing techniques were required if plans were to be current and complete without the formation of vast planning staffs to perform essentially clerical tasks.

The first base development plans prepared under the new regulations were done by ESSG at the direction of the Department of the Army. One plan was to be completed by ESSG for each major theater where Army elements were stationed to help the theater planners get started in their own base development planning. To perform this task, ESSG began development of a planning system, actually a management information system, capable of providing the output required by the JCS regulations and based on the contingency operation plans prepared in the various theaters. The system was named CATECODE and the system development proceeded in an evolutional manner as various plans were prepared. At this writing the system development is still underway. Although the base development plans were prepared by ESSG, they continued to be the responsibility of the theater commander concerned and were subject to his approval before acceptance. An early aim of the CATECODE system development was to provide a generalized information system which could be employed at the theater level and thus facilitate planning by permitting preparation of base development plans at the same command level and location as the parent operation plan.

III. THE CATECODE SYSTEM

The specific objective of the CATECODE system development was to provide a base development planning system capable of producing a plan in the detail and format required by Joint Staff directives. The requirement for a given base development plan is initiated in the development of an operations plan which is designed to fulfill some national defense commitment. The sequence of events begins with the development of a draft operations plan defining missions, force structures (to include available logistical troops), and the schedule for the phased build up of troops in the objective area. The development of a logistics plan, of which the base development plan is a part, follows within the guidelines established by the draft operations plan. As the logistics plan development proceeds and the logistics requirements of the operation plan are compared with the resources available, shortfalls are usually determined. This begins an iterative procedure with interaction between the operational and logistical planners in which various trade-offs in requirements and capabilities are investigated. The cycle continues until an operations plan capable of accomplishing the mission dictated by the national commitment and a logistics plan capable of supporting the operations plan are achieved. Both plans then become a single formal document which is submitted for review and approval at higher levels of command. The CATECODE system was intended to provide the group of logistical planners responsible for the

base development portion of the logistics plan with a computer-assisted information system to facilitate the preparation of their plan in the iterative planning cycle.

In August 1970, development of the second version of the CATE-CODE system was completed and the system was informally documented [Ref. 16]. The developing agency, ESSG, intended this version to be an intermediate step towards a final version of a base development planning system to be known as CASTLE (Computer-Assisted System for Theater Level Engineering). It was the second version of the CATE-CODE system upon which this paper was based.

A. COMPUTATION OF CONSTRUCTION REQUIREMENTS

An operations plan normally contains a schedule specifying the location and time of unit deployments required for accomplishment of the mission. In addition to identifying specific units, the operations plan summarizes the troop population to be present in each base area by time periods. Time periods are commonly denoted as D-DAY, D+10, D+20, etc., indicating the deployment date and the days subsequent to deployment. The length of these periods may vary within the plan; for example, during the first part of the operation, ten day periods may be specified, and thirty day periods may be used later. The time periods usually cover the first six months of an operation. As an example, one current plan for the European theater included deployment data for the first one-hundred-eighty-five days of the

operation using ten day periods at first, then thirty day periods and finishing with one thirty-five day period.

The automated CATECODE system considers each base area separately and, using inputted "planning factors", determines the gross facilities requirements by category code. Planning factors are parameters which have been determined by various methods including: historical data, experience, and analysis. They specify such things as: consumption rates per man for various types of supplies, and the number of days of supply which are to be stored at various distribution levels. <u>Staff Officers Field Manual - Organizational, Technical, and Logistical Data, FM 101-10-1</u> [Ref. 11] is a common source of planning factors and related information. Category codes are assigned to the numerous types of facilities by Department of Defense directive and each code number represents a type of facility which fulfills a unique requirement; for example, "214" denotes a maintenance facility for tanks and automotive equipment, and "422" represents ready issue ammunition storage. Gross requirements for each category code at each base area, and for each time period are computed. These gross requirements are then adjusted to account for war damage using damage factors inputted by the planner. Damage factors vary with category code and time period.

Existing assets in each base area are determined from engineer intelligence or actual on-site inspection if possible, and the assets are

deducted from the gross facility requirements for each category to determine the net facility requirements.

The net requirements are translated to construction requirements by selecting appropriate facilities or installations from the Engineer Functional Components System (EFCS) [Ref. 9 and 13], an existing computer-based information system. The EFCS consists of standardized facilities, installations and equipages designed for use in mobilization. Planner input specifies the EFCS facilities to be applied against each construction category, and the operational priority of each category. Priority designations are:

O - Operational requirement, mandatory for the performance of the mission.

D - Direct support requirement, essential for proper performance of the mission.

I - Indirect support requirement, necessary for the proper performance of the mission over an extended period of operations.

The construction category priority designator is automatically assigned to all construction projects in that category.

All projects are assumed to start thirty days prior to the time period in which they are required except for those required before D+30. These are assumed to start on D-DAY.

The computation of requirements phase of the CATECODE program terminates with an intermediate report for planner use consisting of a partial project list (by base area) identifying the portions of projects to be accomplished in the specified time periods. The information

included on the print-out is retained in computer storage for later use.

B. COMPUTATION OF CONSTRUCTION CAPABILITIES

Construction requirements in the CATECODE system are computed external to the system programs. The man-hours of construction effort per time period available from engineer construction troops are computed from the deployment schedule in the operations plan, and are frequently augmented with indigenous labor man-hours when the planner can determine their availability. The total man-hours available per time period are inputted to the program without regard to the base areas.

C. REQUIREMENTS VERSUS CAPABILITIES ANALYSIS

Requirements versus capabilities analysis in the CATECODE system is limited to the situation where the requirements in a time period exceed the capabilities. The construction project list is sorted first by construction priority, then by the time period originally required within construction priority, and finally by base priority within the time period (base priorities are inputted by planner). Projects are then taken from this ordered listing and scheduled for construction as long as capability remains in the time period. The first project which exceeds the construction capability is split into two parts, a scheduled portion and a deferred portion. The deferred portion is then scheduled for accomplishment in the next time period and the remaining projects

on the ordered list are considered again, along with the projects originally scheduled in the subsequent time period. When a project is deferred to a later time period, the program recalculates the war damage portion of the project using the appropriate damage planning factor for the later period.

When the project scheduling has been completed for each time period, all projects which have been deferred beyond the last time period considered are grouped as deferred projects. The program then sorts and provides an output listing in the specified format. The output lists projects by base, priority within the base, and time period within the priority. Projects deferred beyond the final time period are listed separately by base.

In summary, the CATECODE system performs requirements versus capabilities analysis by simply deferring projects until the capability is available to accomplish them, with the construction capability being considered fixed by the engineer unit deployment schedule.

IV. THE REQUIREMENTS VERSUS CAPABILITIES PROBLEM

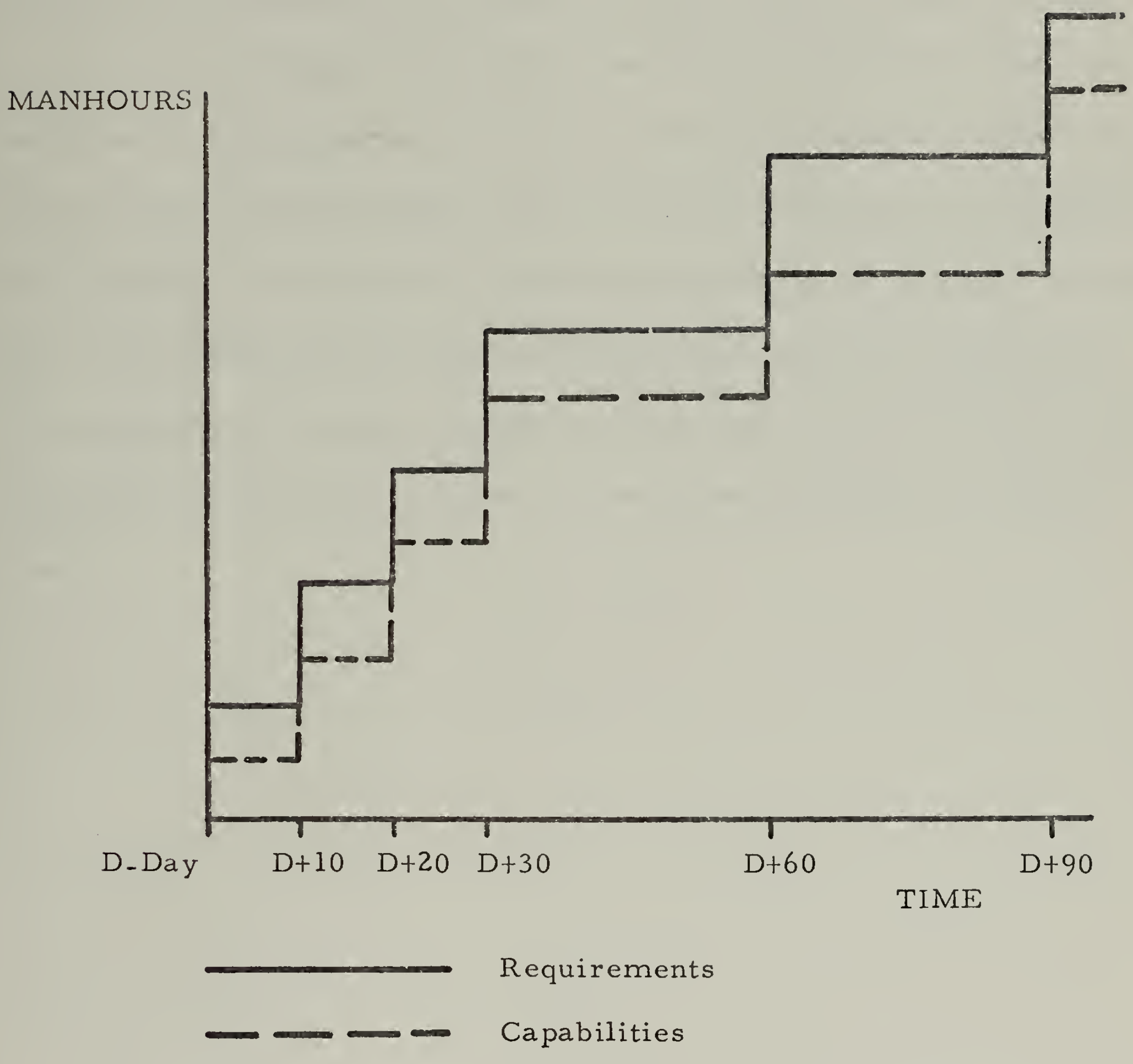
The problem of matching requirements to resources capable of fulfilling the requirements is certainly not unique to the base development planning process. Industry has a quite similar situation with the production smoothing problem; that is the balancing of production levels to compensate for the cyclic nature of demand [Ref. 4, 20, 21, 22, 28 and 29]. The operation plan and each of the other plans included in the logistics annex also require the determination of the resources needed to perform a given task and the resources available to perform the task. Seldom, if ever, are the resources required equal to the resources available. If the resources available exceed what is required to accomplish the task, the action necessary to align the two is relatively simple: either delete those resources which exceed the requirement and the mission can still be performed, or use the construction resources to prepare facilities ahead of schedule. The more challenging case, and the situation most frequently encountered in practice, is where the requirements exceed the capabilities. Here numerous alternative decisions are available to balance requirements and capabilities. The alternatives, which are discussed in detail later in this paper, range from altering the nature of the original task such that the requirements to fulfill it are reduced, to the acquisition of more resources at some cost or detriment elsewhere. In either case the objective is to

perform the original mission, or some modification of it which higher authority approves as being sufficient to meet their higher level objectives.

The requirements versus capabilities problem in the base development planning process is complicated by the time phased structure of the plans involved. Requirements and capabilities are computed in terms of man-hours at discrete points in time, such as D+10, and then they must be aligned for the prescribed time period following the point on which the computations were based. Figure 1 illustrates the situation. An additional problem is introduced if the more realistic situation of a continuous deployment is considered; that is where requirements and capabilities change daily as forces are deployed. The problem of the continuous nature of requirements and capabilities is discussed in a later section of this paper.

The current version of the CATECODE system determines the construction requirements in terms of man-hours and the time period in which the facilities are required and then, holding construction capability in each time period fixed, defers the projects on a priority basis until the total requirements equal the total capabilities in each time period.

The CATECODE system approach to requirements versus capabilities analysis removes practically all of the decision alternatives available to the planner in a manual system, and approaches a "closed" system. The "closed" system also prevents much of the interaction



REQUIREMENTS AND CAPABILITIES VERSUS TIME

Figure 1

between the base development planner, the other logistical planners, and the operations planners. Changing the construction priority of category codes, augmenting the capability man-hours based on manual computations, and changing the basic planning factors are the only alternatives available to the planner. These represent major changes to the plan and require a complete rerun of the system programs. To facilitate the investigation of the many planning trade-offs available and the interaction with the other planners in the development of a complete, co-ordinated operations plan capable of performing the assigned mission, more discriminating decision alternatives are required in the system. The objective of this paper and the related research was to identify and document such decision alternatives and to provide guidance on their use.

V. A SOLUTION

The job of developing a procedure to facilitate the requirements versus capabilities analysis was assigned to the author during his experience tour with the Engineer Strategic Studies Group. At that time, the first version of CATECODE had been developed and documented [Ref. 15] and the second version was practically complete. The research and analysis reported in this paper was performed with the objective of providing a technique to be implemented in later versions of the CATECODE system. This chapter recommends modifications to the existing system which provide the planner a more flexible means of requirements-capabilities analysis.

A. THE APPROACH

Initially, two areas were consulted for assistance in developing a technique for the requirements-capabilities analysis. First, other automated logistics models which addressed the base development planning process were examined, and second, the existing manual and semi-automated procedures were analyzed.

Two models developed by the Research Analysis Corporation (RAC) were investigated: "Program for Estimating Construction Requirements" (PRESCORE) [Ref. 26], and "Simulation and Gaming Methods for Analysis of Logistics" (SIGMALOG) [Ref. 27]. Neither model included a procedure to enable the balancing of requirements and capabilities. The PRESCORE

system (completed in April 1968) computed construction requirements for a specified scenario, and the SIGMALOG theater construction model used the PRESCORE model to develop requirements and then computed the construction capability necessary to fulfill the requirements. The RAC models were developed with the objective of assisting the logistics planner, but did not include a method of investigating planning trade-offs.

Next, the manual and semi-automated planning procedures which were in use were probed. Members of the staff of the Engineer Strategic Studies Group, who had been active in the preparation of the first plans which met the new JCS requirements, were interviewed to determine what techniques they had employed to bring requirements in line with capabilities. It was found that numerous alternatives had been exercised, most of which were based on "common sense" and "experience." The Base Development Planning Guide provided some general guidance as to which alternative decisions should be considered, but detailed instructions had never been documented. The decision rules which the manual planners had used were consolidated and several others which they had not used were added, and these alternatives are discussed in the next section of this paper.

The modifications and changes to the CATECODE system which were required to allow the planner to investigate alternative decisions were then considered. The author intended to develop a computer model to demonstrate the use of these decisions in the CATECODE system, but unfamiliarity with the computer language used in CATECODE and

the more sophisticated systems programming problems involved prevented this.

B. THE DECISION ALTERNATIVES AVAILABLE

Although a vast number of alternative planning decisions are available in the general base development planning process, the specific operation and objective areas involved impose constraints which may preclude the use of some or all of the alternatives. The iterative planning cycle, which involves both the operational and logistical planners, reveals which alternatives are appropriate for the particular mission in question. This section describes the alternatives available and the situations in which they can be used.

1. Utilization of Engineer Construction Troops

One obvious means of balancing requirements and capabilities is to provide additional construction troops in the deployment schedule. Ordinarily the draft operations plan provides for the deployment of all logistics units and additional units are not available. In some instances however, if appropriate justification can be provided, higher headquarters may be able to provide more resources than initially allocated for the operation. Another alternative is to deploy the troops already committed to the operation earlier. This decision increases the total construction effort available during the deployment, but it also requires that the units concerned be able to meet the accelerated deployment schedule.

2. Indigenous Augmentation

Both skilled and unskilled labor can often be obtained from the civilian population in the area of operations. These resources are normally employed under the supervision of engineer troops and greatly increase the man-hours of construction capability. The availability, levels of skill, and willingness to cooperate with United States forces can be determined by intelligence agencies, and estimates can be made of the increased construction capability available.

3. Other Construction Methods

Three construction methods are available which do not require a significant diversion of engineer construction resources.

a. Construction Contracts

Frequently contractors, both US and foreign, can be utilized to accomplish specific construction projects or groups of projects. United States embassies can provide information on the location and capabilities of contractors, and using this information and estimates of the survivability of the capabilities during hostilities, the planner can designate construction requirements which can be accomplished by contract. Care must be exercised to insure that the transportation planner considers the movement resources, if any, that the contractors may require from military sources.

b. Using-Unit Self-help

Extensive use of using-unit capabilities has been made in Vietnam to reduce the requirement for engineer troops. Troop billets,

personnel support facilities, and administrative buildings are particularly suited to this method of construction. Other logistics planners should be made aware of the magnitude of self-help undertakings which may affect other support functions.

c. Pre-hostilities Construction

When political and diplomatic considerations permit, pre-hostilities construction can be used to reduce the construction requirements of an operations plan. Highways, airfields, railroads, and port facilities can be constructed or improved under the sponsorship of various foreign assistance programs, thus improving the domestic position of the host nation as well as fulfilling the military purpose. The planner must consider the ability of the enemy to capture, damage, or destroy these facilities following the outbreak of hostilities.

4. Deferring Construction Requirements

Construction projects required in early phases of the operation can be deferred to later phases when construction capability is not available. The planner can make such changes based on the priorities assigned to projects initially or by revised priorities which he may consider appropriate as the planning cycle progresses.

5. Deletion of Construction Requirements

Under some circumstances, the planner may decide to eliminate some construction projects completely.

6. <u>Change of Construction Standards</u>

The Engineer Functional Components System, which is used to translate the net facilities requirements into a listing of construction projects, designates several construction standards which are capable of fulfilling the same basic military requirement. Standard 3 is normally used in the computation of facilities to support contingency plans, and provides frame buildings with concrete floors for administrative, mess and supply activities, and squad tents with concrete floors for troop billets. In contrast, Standard 2 specifies all facilities and billets in tents without floors and lower quality roadway preparation. Thus, significant reductions can be made in construction requirements by lowering the construction standard. The planner must consider the physical environment and the anticipated duration of the operation when contemplating such a decision.

C. CRITERIA FOR SELECTION OF ALTERNATIVES

The previous section of this paper described the alternative decisions available to the base development planner in his attempt to balance construction requirements with capabilities. These alternatives are constrained by the nature of the operation, and by the combat commander's desires. The primary constraint is the nature of the operation which considers the terrain and climate of the deployment area, and the type of warfare; that is, limited, guerilla-style conflict, conventional warfare, or a nuclear exchange. The strategy of the operation

commander is a second constraint as the base development plan must support the operation as he directs it. Since the nature of operations varies from theater to theater and two commanders rarely favor identical strategies, a generalized system such as CATECODE must provide considerable flexibility in the selection of alternative decisions. The alternative, or combination of alternatives, which provides a "best" base development plan in one area or for one commander, may not be acceptable under other circumstances. Therefore, the selection of the decision, or set of decisions, required to provide a "feasible" base development plan should remain in the hands of the planner and his superiors, and the criterion by which one plan is judged better than another should also be determined by the commander and planner involved. Certain situations favor the selection of specific alternatives however, and this section of the paper includes some guidelines to assist the planner in his selection.

During the first several months of a contingency operation, engineer construction troops are usually the greatest and most readily available capability for construction in support of the base development plan. In addition, limited use of non-engineer troops for self-help projects is possible in the early stages of the operation. Care must be taken to avoid over-committing the other forces to construction efforts which may prevent them from performing their own mission. Engineer construction units and other forces are capable of defending themselves in dispersed locations during the early phases of the

operation whereas contract forces are not. Indigenous labor augmentation can be utilized by both construction and non-construction units during the initial phases of the operation, but the planner must be cautious in predicting the capability of such augmentation.

As the operation progresses, the original construction units may be augmented by construction contractors. Contractor forces are generally tailored for specific type endeavors, require considerable time to mobilize at a particular site, and require comparatively extensive base facilities to sustain them. They are usually employed at relatively secure locations whereas troop units are adaptable to forward areas and to dispersed requirements not economical for fulfillment by construction contractors. Contractor capabilities should be employed only in areas containing a large volume of work in order to offset the relatively high costs of mobilization and subsequent support. In general, the contractor effort is best suited to heavy construction such as airfield paving, waterfront structures, and aggregate production. Specialty contractors can be used for sophisticated requirements such as communications facilities and utility systems.

When high priority requirements in the first phases of the operation cannot be met using other available resources, pre-hostilities construction should be considered. If the political climate of the host nation is favorable, foreign assistance programs can be used. Projects which are not strictly military in nature, such as airfields, roadways, and port facilities, are best suited for this type of construction.

Lowering construction standards and deferring requirements should be considered after the other alternatives. Reducing construction standards can fulfill the basic military requirement, but at reduced efficiency; and deferring requirements can satisfy the requirement, but at a later time. One combination of these alternatives is to use lower standards during the early phases of the operation, and provide for upgrading to the required standard later in the operation. The planner must analyze the particular circumstances and determine which alternative, or combination of alternatives, will best support the given mission.

Deleting construction requirements should be considered a last resort, and should only be used when the planner can determine the mission will not be seriously affected.

The experience and judgment of the planner is the most important single element in the analysis phase. The planner must consider the effect his decisions will have on the mission performance of the other forces; and, in coordination with the other operations and logistics planners, arrive at the plan which he feels is the "best" plan to support the assigned mission within the resource constraints. The quality of the plan is a result of the subjective judgment by the planner, and subsequently by his commander.

D. INCLUSION OF DECISION ALTERNATIVES IN CATECODE

To establish the changes in the CATECODE system necessary to allow the planner to use the available alternatives, an analysis of the output required to make such decisions was made.

1. <u>The Required Output</u>

The intermediate report which the current CATECODE version produces before entering the requirements versus capabilities analysis phase was selected as the starting point since this report is a listing of the construction projects required to support the operation as initially planned. This report contains all the output data elements required by the JCS directives, and the file which creates it is stored for input to the current analysis routine. The solution proposed by this paper begins with this project file.

The existing project file should be sorted first by time period, then by base and base priority within the time period, and finally by project priority within the base. An additional column should be added to the current report format in which an entry can be made to indicate whether capability is available to complete a project. Four new data elements should be added to each time period block and each time period by base block. These elements are the total number of man-hours necessary to complete each of the three project priority groups and the man-hours necessary for all three priority groups. Figure 2 is an illustration of the output recommended with the new elements annotated. Using the output in this format would permit the planner to determine which projects can be constructed at each base and the man-hours necessary to complete the rejected projects by priority at each base, and by priority for all bases.

```
                         BASE CONSTRUCTION PROJECTS
OPLAN 73-69                                                       HQUSBIGAL

PROJ   USING  PRI   TIME    DOD                             CONST   CAP
NO.    SVC    CODE  PHASE   CAT                             BY      AVAIL

BASE XXXX PRI 01

0006A  W      O     D-DAY   723A                            T       Y
0007A  W      O     D-DAY   723A                            T       Y
0012A  W      O     D-DAY   111       EXISTING OUTPUT       T       Y
...    .      .     ...     ...                             .       .
...    .      .     ...     ...                             .       .
0036A  W      D     D-DAY   469                             T       N
...    .      .     ...     ...                             .       .
...    .      .     ...     ...                             .       .
0062A  W      I     D-DAY   823                             T       N
...    .      .     ...     ...                             .       .
MNHRS REQD  PRI O 00986  PRI D 02489  PRI I 07598  ALL 011073
BASE YYYY PRI 02

1006A  W      O     D-DAY   723A                            T       Y
1007A  W      O     D-DAY   723A                            T       Y
1009A  W      O     D-DAY   111       NEW DATA ELEMENTS     T       N
...    .      .     ...     ...                             .       .
...    .      .     ...     ...                             .       .
MNHRS REQD  PRI O 00120  PRI D 05864  PRI I 00209  ALL 006193

ALL BASES TOTALS
MNHRS REQD  PRI O 01106  PRI D 08353  PRI I 07807  ALL 017266

BASE XXXX PRI 01

0006B  W      O     D+10    723A                            T       Y
0007B  W      O     D+10    723A                            T       Y
...    .      .     ...     ...                             .       .
...    .      .     ...     ...                             .       .
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RECOMMENDED INTERMEDIATE OUTPUT FORMAT

FIGURE 2

2. Additional Input

After the output necessary for the decision making process was determined, the decision alternatives were examined to find what additional input was required to provide the desired output.

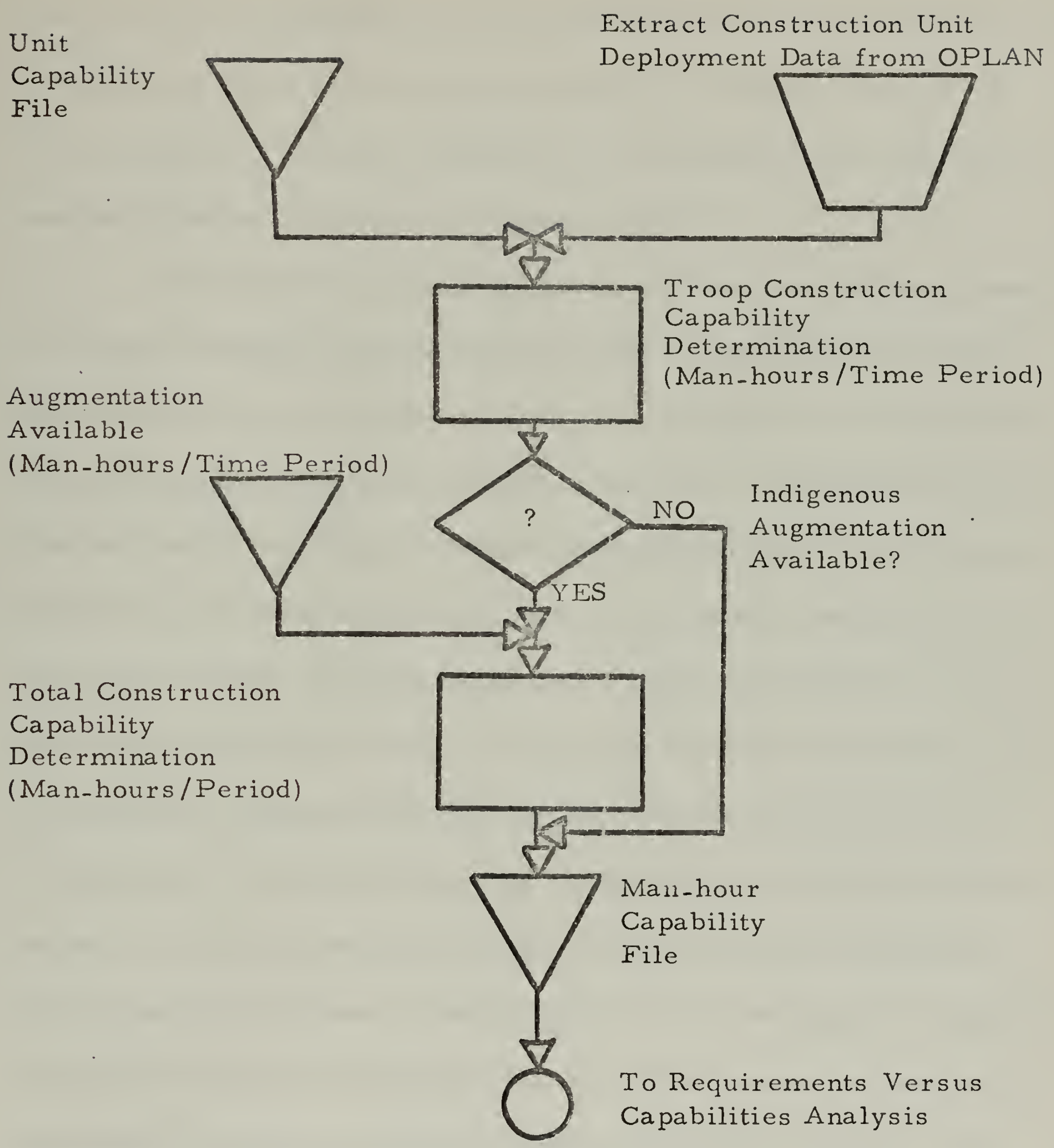
In order to change construction standards, it is necessary to recompute the construction requirements. This requires that the initial portion of the CATECODE system be rerun and a new project file be established. To use this alternative, the planner must return to the initial CATECODE input and make the desired changes. When the project file based on the lowered construction standards is computed, the planner can continue the requirements versus capabilities analysis by considering the other decision rules.

All other decision alternatives discussed previously can be exercised without recomputing the initial project file. Several changes in the method of inputting construction man-hour capabilities are recommended however. The current input to CATECODE requires external, manual computations to determine the man-hour capability by time period available from the engineer units as they deploy. These computations require the planner to extract the unit deployment data from the operations plan, identify the table of organization and equipment (TOE) of each engineer unit, determine the capability ascribed to each TOE from planning factor data, and sum the capabilities available in each time period. If indigenous labor augmentation is assumed to be available, the man-hours are added to the troop hours,

and the total man-hours available in each period are inputted for the requirements versus capabilities analysis. Two modifications are recommended to eliminate the manual calculations, but more importantly to permit the investigation of planning trade-offs which will be discussed later. First, create a new engineer unit capability file identifying the construction capability of each type of unit (normally ten construction unit types are available), and second, change the input data extracted from the operations plan to identify only the TOE number, the number of units of that TOE to be deployed, and the time period in which the unit is mission effective. The man-hours capability in each time period can then be computed by the system and placed in a man-hour capability file. If indigenous augmentation is available, the man-hours available in each time period can be inputted and added to the troop capability. Figure 3 outlines this procedure. The man-hour capability file then becomes an input to the requirements-capabilities analysis routine.

3. Recommended Requirements Versus Capabilities Analysis Technique for CATECODE

The recommended analysis routine has two inputs: the project file and the man-hour capability file. The routine determines which projects can be completed within the capability available in each time period. The priority of the project category is considered first and then the priority of the base for which it is required. The routine outputs intermediate planning documents on which projects



RECOMMENDED CONSTRUCTION CAPABILITY COMPUTATION

Figure 3

that can be accomplished are designated with a "Y" in the "CAP AVAIL" column, and those which cannot be done are designated with an "N". The "CONST BY" column contains a "T" to indicate construction by engineer troops with indigenous augmentation.

After the first run the planner receives intermediate planning documents showing which projects can and cannot be accomplished, and the number of man-hours required to complete the various priorities of projects at each base and for all bases. At this point he is in the position of analyzing the output and implementing the appropriate alternative decisions to balance requirements and capabilities. As previously stated, the decisions which a planner can make are constrained by the mission, the environment, the tactical situation, his commander's guidance and other factors too numerous to list. By comparing the outcomes of various combinations of decisions however, he can arrive at a plan which is more likely to fit the commander's objectives than the plans produced under the current analysis technique. Decisions are made and the project file is run against the man-hour capability file again to produce another intermediate report. The initial project file is retained throughout the process and a second project file is continually updated as the planner inputs various decisions. When requirements and capabilities are equal for each time period, the iterations stop and the final output documents are requested and provided in the JCS format.

The planner's analysis at each iteration is essentially a thought process to determine which decisions are appropriate. Initially, he examines the complete intermediate planning documents and observes that some high priority projects have been rejected because capability is lacking. He then selects decision alternatives as discussed in Section V-C and begins the analysis. He can investigate what projects can be accomplished if additional troops are requested, or if the troops included in the plan are deployed earlier in the operation. The input for such a decision specifies the number and type of construction units and the time period in which they are available. The recommended procedure recomputes the construction capability by time period and then runs the project file against the updated capability file. The planning documents from this run are then compared with the output from the previous run, and the outcome of such a comparison can provide justification for additional resources or accelerated deployment of construction troops. The intermediate planning documents after the initial run indicate only those projects whose status has been changed, and the current man-hour totals by priority and base. An option is available to allow the planner to request a complete intermediate document if desired.

The planner can designate certain projects to be accomplished by the other construction methods previously discussed. These decisions are implemented by designating the project or groups of projects which are to be done by other means and rerunning the

analysis routine. The routine does not deduct the hours required for these projects from the man-hour capability file, and the output notes the projects by a "C" for contract construction, an "S" for self-help construction, and a "P" for pre-hostilities construction in the "CONST BY" column. A "Y" is placed in the "CAP AVAIL" column indicating the projects can be accomplished.

As noted earlier, the planner can change construction standards but this requires that the initial system input be changed and a complete rerun made to establish a new project file.

Projects can be completely deleted by designating the number(s) of the projects(s) to be removed from consideration.

Projects can be deferred to later time periods by designating the number(s) of the project(s) to be deferred and the time period to which they are deferred. In addition, an option to defer all projects for which capability is not available is offered. This decision allows the planner to have all projects deferred automatically as the present CATECODE system does. This decision alternative is particularly well-suited for use after the planner has used the other decision alternatives to insure that the highest priority projects can be accomplished. He then defers the remaining projects until capability is available. This is the logical decision rule to use when ending the planner's analysis.

E. EVALUATION OF THE RECOMMENDED SOLUTION

The solution which has been proposed in this paper allows the planner using the computer-based CATECODE system far greater flexibility in the base development planning process than is currently available. The author is not so naive to believe, however, that an ultimate or optimizing solution has been reached. It is felt that the decision rules documented here come close to exhausting the practical alternatives available to the planner; but, because the solution has not been subjected to detailed analysis by a qualified programmer, the recommended requirements versus capabilities analysis technique may present machine-constrained problems not evident to this writer. The next section of this paper discusses some other problems which are recognized as being present in the implementation of the recommended solution and the CATECODE system.

VI. IMPLEMENTATION OF THE SOLUTION

The proposed requirements versus capabilities analysis technique is compatible with the current CATECODE system which operates on a UNIVAC 1108 computer with mass storage capability. The computer is operated by the Army Topographic Command which is colocated with ESSG. The various theater planners submit their operations plans to ESSG, and their staff prepares the supporting base development plans and returns them for approval by the theater commanders. The long range objective of the CATECODE system, and its ultimate product, CASTLE, is to provide a system to be operated at the theater level. The final system design, therefore, must be capable of being operated on the smaller, less sophisticated, hardware in the theaters; or on time-sharing terminals. The COBOL language is used in CATECODE and this is compatible with all Army equipment [Ref. 6, 7, and 8].

The recommended technique for the planner's analysis is readily adaptable to a real-time computing system [Ref. 19 and 24]. Cathode-ray data display devices can be used to facilitate the communication between the planner and the computer. The reporting of only those projects whose status changes at each iteration, and the inclusion of man-hour totals for unfulfilled requirements permit the planner to act without examining voluminous, hard-copy output. Such equipment is not generally available at military data processing installations,

but might be justified on a cost-savings basis. Time-sharing terminals at remote locations must be serviced by properly secured communication lines and shielded computer installations because of the security classification of the data involved.

The major step towards successful implementation of the procedure recommended and the CATECODE system is the training of the planners who will use the system. In order to train the planners, however, two preliminary actions are required. The complete system must be fully documented, and a prototype model developed to demonstrate the system's use. The documentation should serve both as a training manual and a system operations manual; with especially careful explanation of the methods required to prepare the initial and intermediate inputs to the system. Complete description of the planning alternatives and the operation-peculiar constraints which may prevent their selection must be stressed. The people trained should be the individuals actually charged with the responsibility for preparing base development plans in the various theaters. The senior members of the planning staff will be required to present the plans for approval by the theater commander, and they should be able to explain or defend the plans. To do this properly they must be fully aware of the planner inputs to the system and the full range of decision alternatives available.

VII. UNRESOLVED PROBLEMS IN THE BASE DEVELOPMENT PLANNING PROCESS

The analysis of the manual and semi-automated base development planning process, the early versions of the CATECODE system, and the RAC models revealed some other problem areas which require more analysis to determine their impact on base development planning. Brief descriptions of these problems are documented here.

A. DETERMINATION OF REQUIREMENTS

Construction requirements in the CATECODE system are based solely on population-related planning factors. This is not entirely valid since the units into which the population is subdivided have different missions, different equipages, and hence, different logistical requirements. A more valid means of computing requirements might be to determine the particular construction requirements of a particular type of unit, and then accumulate the requirements by the base area in which the units are assigned.

B. DISCRETENESS OF THE PLANNING PERIODS

The CATECODE system and other models examined compute both requirements and capabilities in time periods of from ten to thirty-five days. The actual deployment of units into a theater of operations is a continuous process with a daily increase in population

and logistical requirements. Is there an efficient method to handle the computation of requirements and capabilities on a continuous basis?

C. DEVELOPMENT OF THE EXECUTION PLAN

The base development planning process produces a plan which balances requirements and capabilities but it does not provide a plan for the actual execution of the construction effort after the outbreak of hostilities. The problem of determining the actual construction units which will accomplish specific projects, and their locations could be addressed in the planning phase.

D. POINT ESTIMATES

The effort required for the construction of various EFCS facilities and the construction capability of engineer construction units are expressed as point estimates in units of man-hours. No variability in the estimates is considered for either capabilities or requirements, other than percentage corrections for climatic conditions. The effect of natural variation in the man-hours required to construct the EFCS facilities and in construction unit capabilities should be analyzed. One possible method of attacking this problem is to do sensitivity analysis using the system prototype. The effect of variability in the man-hour requirement for various EFCS facilities on the construction requirements and the construction resources could thus be determined.

E. AN OPTIMAL SOLUTION

In both the manual base development planning methods and the modified automated system proposed in this paper, the quality of the base development plan is determined subjectively. The set of decisions which the planner uses in arriving at what he considers to be the "best" plan is selected using judgment alone. There is no means of "optimizing" to determine the set of alternatives which is the "best possible" to either maximize or minimize some objective function. Numerous efforts have been made [Ref. 4, 21, 22 and 23] which attempt to provide an optimal decision policy for the analogous industrial problem of production smoothing. Mathematical programming has been the most popular technique in these efforts, and it could provide an optimizing algorithm for the selection of alternatives in the base development planning process. The problem of selecting an objective function and appropriate constraints presents the greatest obstacle in such an approach.

VIII. SUMMARY AND CONCLUSIONS

Recent experience in Southeast Asia has demonstrated the necessity for more detailed logistical planning in conjunction with contingency operations. Significant advances have been made in the area of base development planning and the progress is continuing. The CATECODE system is the most prominent effort by the Army, but the current version does not permit sufficient flexibility in the investigation of the numerous planning trade-offs available. This paper proposes a solution to this problem. The implementation of the automated base development planning system requires extensive preparation, most notably in the area of planner training. Some basic areas remain to be examined in the present base development planning methodology.

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13. ABSTRACT

This paper presents a computer-assisted technique for requirements versus capabilities analysis in base development planning. The decision alternatives available to the planner are examined and a procedure for implementation in the planning process is proposed. Some unresolved problems in current base development planning methodology are described.

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